CONCRETE METALLIC FIBERS IN THE ARCHITECTURAL DESIGN

(Study of physicochemical characteristics and optimization of its formulation)

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ABSTRACT:

For twenty years, the study of building materials including concrete adopted more scientific approaches. It seeks to identify the phenomena, physicochemical underlying the behavior of concrete. Indeed; the field of building materials has gone through many changes to improve the provision of both rheological material plane as the plane of the structure, such as fiber reinforced concrete. This study is part of research of the most successful properties in view of overcoming the disadvantages of conventional concrete, in terms of mechanical strength and post-cracking behavior but also a need to improve the ductility of this material facing various stresses, in favor of the architectural-design.

For this, we considered the sum different formulation methods of fibrous concrete, studying one of the most important criteria that is handling. Focusing more closely to the components of the special reinforcement material (metal fiber), we chose to use two completely different types of fibers to one another. The reinforcing incorporation in the concrete matrix requires optimization of the fiber content because overdosing or underdosing creates an imbalance in the strength and workability of the material.

Therefore, it has been found and this through a comparative approach with a control concrete (without fiber), the influence of the fiber addition on the workability of the concrete is distinct see considerable.

Keywords: Composite, reinforcement, matrix, Concrete, metal fibers, Maneuverability (workability)

INTRODUCTION

At a time of technological expansion in the world including the construction of the building and public works, performance requirements, profitability and sustainability, imperatively demand a search for the most suitable materials. From antiquity, the key component in a project of building was and will undoubtedly be the raw material; all civilizations knew their heyday through materials they were able to master, and their allowed to answer a certain number of basic needs of men. From *Vitruve* passing by *Coophimellblau* to *Le Corbusier*, the conditions imposed by the circumstances, coupled with the vagaries of genius builder, continue on their wander. Whatever the intervention's scale, the building materials have a significant influence and invaluable. Having been used since ancient times, the use of concrete had its heyday from the half of the twentieth century. Thanks to the achievements of science of materials, this composite begans to mark important progress its mechanical properties improved.

One advanced in terms of concrete is that of the incorporation of fibers, which is the simple transposition reinforcements was used since very long time in materials like earth, clay or plaster. This is the fiber concrete comprising a cementitious matrix and metal fibers. Thanks to these many features, the metallic fiber-reinforced concrete is used in many areas of the construction, building envelopes, interior design, furniture urban renovation and rehabilitation, structure ... etc.) To the public works sector (concrete projected as temporary support of the tunnel, piles, precast etc ....)

This article is an introduction to the formulation of fibrous concrete .To be able to understand the behavior of fibers and their contributions in the concrete, it is essential to recall the main current features, which justifies its use, the principle of general operation this material through a quick description of the basic constituent materials. The purpose of this research is to understand the main methods of formulation of an existing fiber concrete, and the various components of the material (matrix and reinforcement) and implemented through an experimental program, all the material in question using two types of fibers completely separate from each other, thereby, determine the main contributions of each on one of the basic requirements in the formulation, of a fibrous concrete which is the maneuverability.

The issue that triggered this research process is: what is the contribution of the fibers on one of the essential characteristics (maneuverability) which is involved in the composition of a fiber concrete? In this article we start from the premise that optimization is to first fix a type and dosage of cement from the initial formulation of control concrete (without fibers) and to vary the amounts of the various aggregates up 'get the S / G ratio (sand / gravel), which leads to the maximum maneuverability and this for a E/C ratio fixed.

For this purpose, at first we will define the theoretical concepts essential to the understanding of fiber concrete material, its components and the interaction fiber / matrix. In a second we will show the process used, curves and interpretation of results

Indeed, as already mentioned in the summary, two types of metallic fiber will be used: hook and flat fiber made of amorphous iron. Two kind of attachment, the first works by hooking **(Fig.01)** while the second kind works by adherence. **(Fig.02)**

Fig. (01) Compression fracture for concrete reinforced with metallic fibers with hooks under compression effort ***Source (7)***

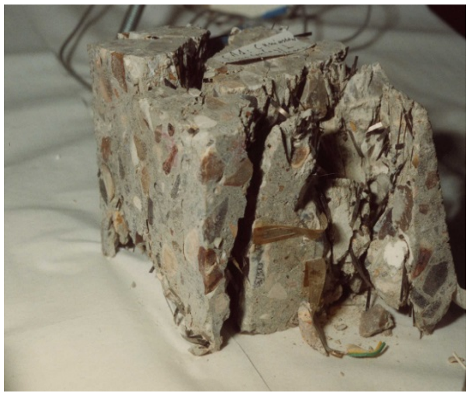


Fig. (02) Compression fracture for concrete reinforced with metallic fibers in amorphous iron under compression effort ***Source (7)***

However in this study we do not concern ourselves with the role of the fiber under load, but its role in optimizing the formulation of the material, matrix / fiber mixture, a turning point where we assay to determine the fiber s' mechanical characteristics of the material to be used in architectural design.

3. FORMULATION BFM AND METHOD USED:

In the literature, there are methods of formulation of fiber reinforced concrete (FRC), where most empirical essentially based on a large number of experimental studies, and lead to recommendations that are not suitable for all uses that is made the (FRC), and not to get the most out of this composite. **(8)**

Therefore, the Central Laboratory of Bridges and Roads (LCPC) offers the so-called BARON-LESAGE, to optimize the granular skeleton of fiber concrete. This method is based on three main assumptions widely verified by experience (8):

- ✓ E / C fixed at the beginning: the best handling concrete is one that has the most compact granular skeleton;

Optimal proportions aggregates do not depend on the nature and volume of the binder;

- ✓ The introduction of the metal fibers does not alter the first two assumptions. In practice, we proceed in 3 stages to compose the FRC:
- ❖ We set out from the water cement ratio (W / C) and the percentage of fibers to be incorporated.

❖ We vary the S / G ratio (sand aggregates), and determine for each report the workability of the concrete fibers. We can therefore draw a curve connecting the maneuverability and the S / G and then determine the S / G ratio report for which the handling is most.

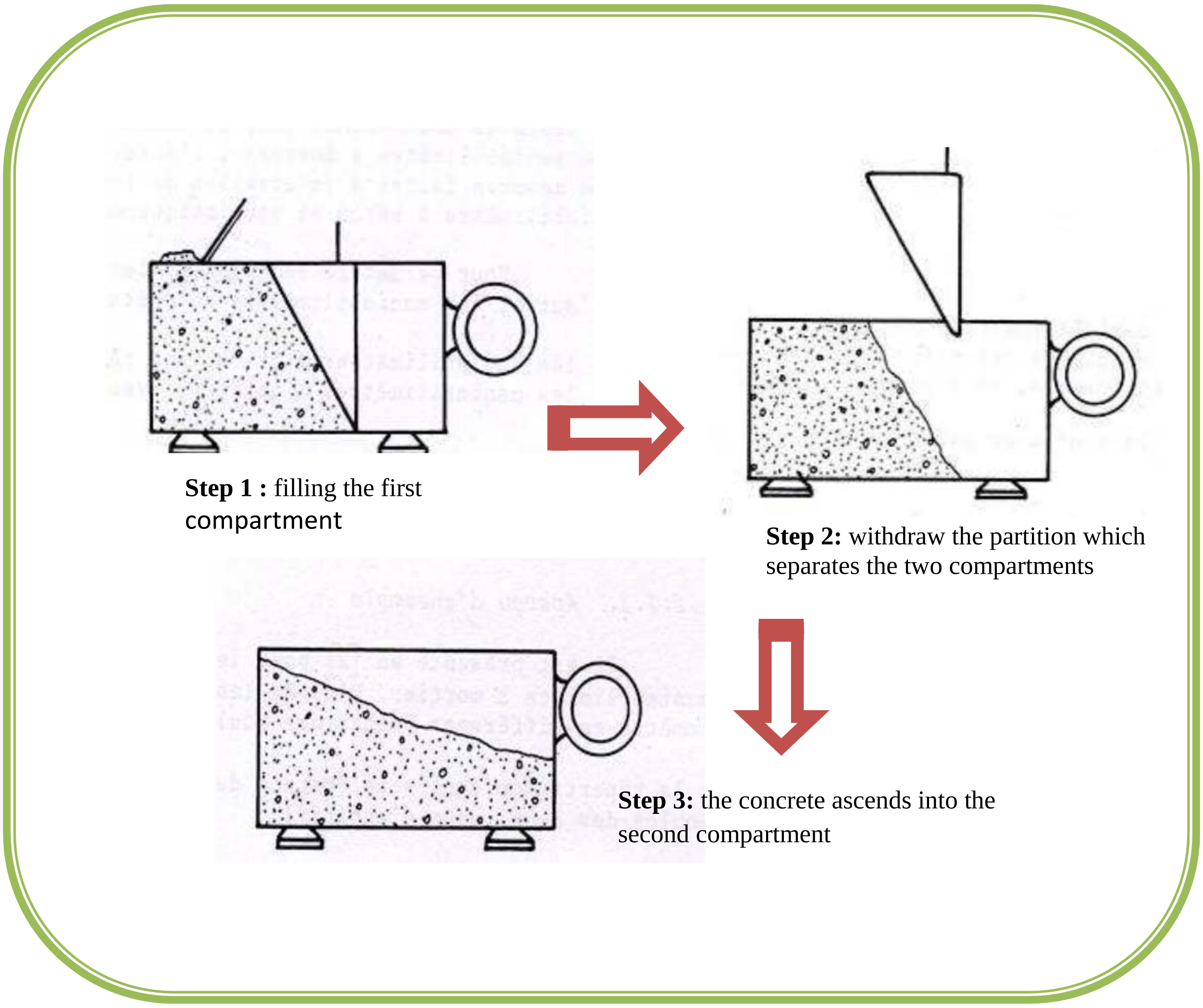


Fig. (03) *Successive phases of the workability test* ***Source(08)***

This study was conducted at a laboratory testing on the construction and building, where the wording of the two types of concrete namely conventional concrete (control) and the fibrous concrete, was based on the use of local materials for aggregates.

CONSTITUTING	MASS (KG)
Sand 0/3	702,35
Gravel 3/8	117.61
Gravel 8/15	976.45
Cement CPJ CEM II/A 42.5 (C)	351
Water (E)	191.21

TAB 1 ***Dosage of the different components***

Fig. (04) *Filling the the machine* ***Source (Author)***

Fig. (05) *weighing the aggregates* ***Source (Author)***

Fig. (06) *Gravel 8/15* ***Source (Author)***

Fig. (07) *Sand 0/3* ***Source (Author)***

Fig. (08) *Gravel 3/8* ***Source (Author)***

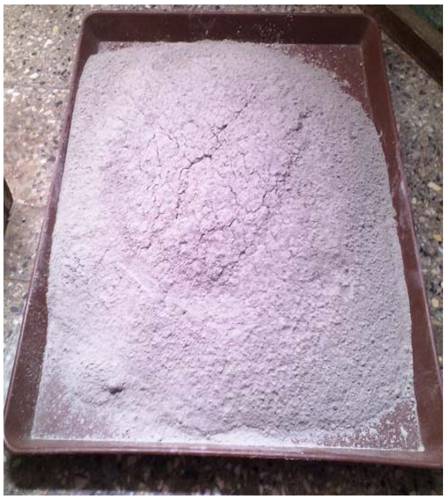


Fig. (09) *Cement CPJ CEM II/A 42.5 (C)* ***Source (Author)***

Two types of fiber have been used, the flat fibers and the hook fibers. The latter are delivered in the form of small packets of contiguous fibers, dissolved once in contact with water.

	Nature	Volumic Mass(kg/m^3)	L_F	l_f	e_f	d_f	V_f (%)
FIBERS	**With hook**	78000	60			0.8	0.5
	Flat fiber	7200	31	0.025	1.7		0.5

TAB 1 ***Dosage of the different component***

Fig. (10) *Fibers with hooks* ***Source (Author)***

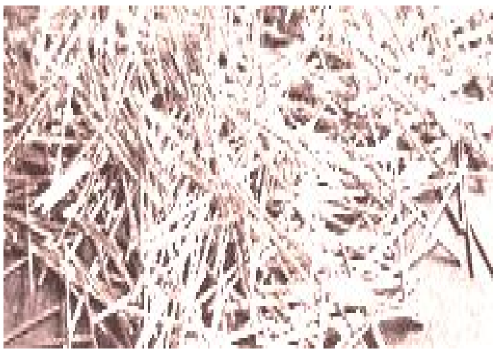


Fig. (11) *Flat fibers made of* amorphous iron ***Source (Author)***

4. OPERATIVE PROCESS :

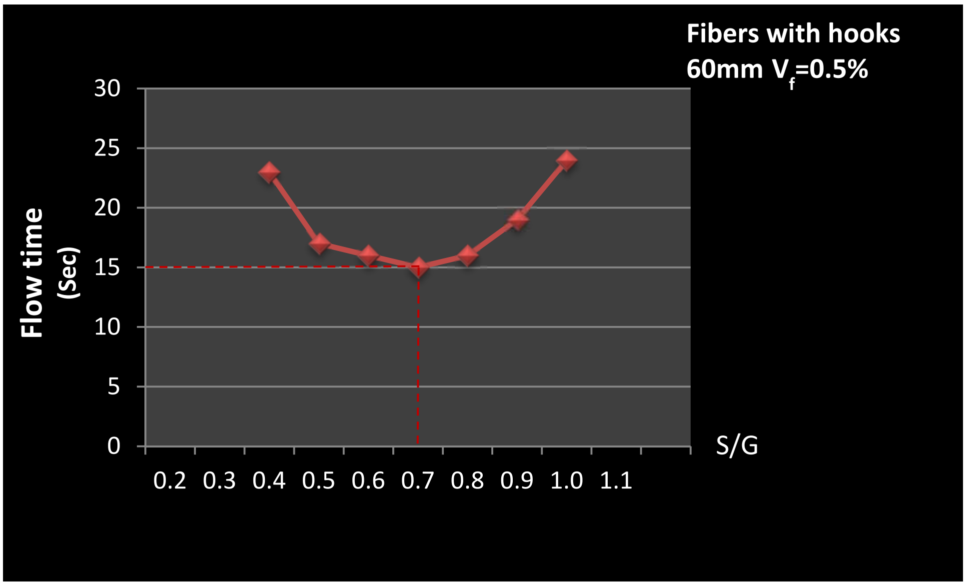
To study the workability of the concrete fiber, we realized for both types of fiber similar percentages (0.5% and 0.5%), ten wasted. Different S / G ratio of:
(S / G = 0.2, S / G = 0.3, S / G = 0.4 and S / G = 0.5, S / G = 0.6, S / G = 0.7; S / G = 0.8, S / G = 0.9, S / G = 1.0; S / G = 1.1;), and an E / C constant set at 0.53.
For all the studied concretes, we imposed maneuverability corresponding to a flow time of between 10and 15 seconds, desired handling on site to the correct implementation of a type of bridge s' concrete.
After completing the handling test, draw a curve connecting workability characterized by the flow time "t", and the S / G ratio (sand / gravel).
In table TAB3, one gets the values of the concrete flow time of fibers obtained for each value of S / G ratio (for each concrete composition the amount of plasticizer added to the mixture is 0.05% by weight of cement , 5.7 g) and then plots the flow time curve S / G see **Graph (3,4,5)**

Fiber (%)	Ratio S/G	Flow Time t (sec)
With hook 0.5%	0.2	-
	0.3	-
	0.4	23
	0.5	17
	0.6	16
	0.7	15
	0.8	16
	0.9	19
	1.0	24
	1.1	-
Flat fiber 0.5%	0.4	-
	0.6	16
	0.8	13
	1.0	8
	1.2	9
	1.4	13
	1.6	16
	1.8	-
	2.0	-

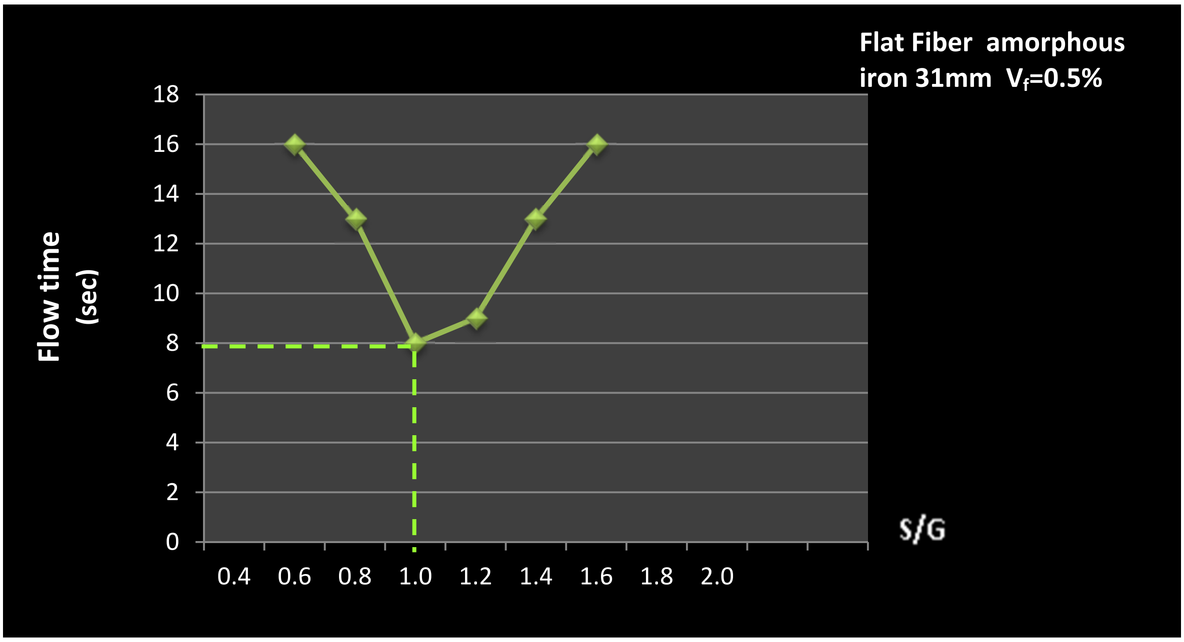
TAB 3. ***Composition used for the concrete metallic fibers***

WITNESS CONCRETE (without fiber)

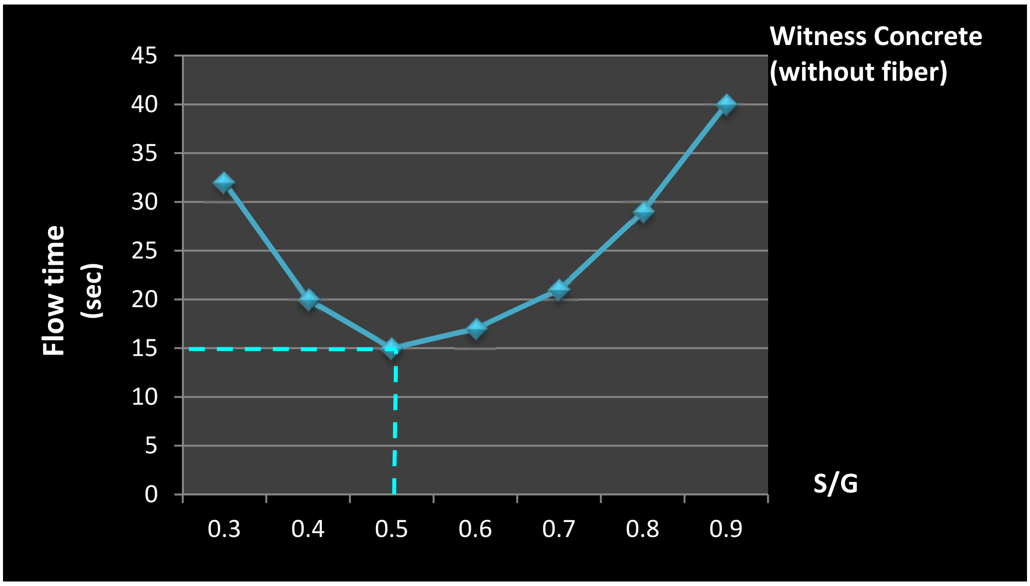
Ratio S/G	Time Flow t (sec)
0.2	-
0.3	32
0.4	20
0.5	15
0.6	17
0.7	21
0.8	29
0.9	40
1.0	-



Graphe1 : *Determination of the flow time in terms of S/G for a concrete reinforced with : fibers with hooks* ***Source : Author***



Graphe2 : *Determination of the flow time in terms of S/G for a concrete reinforced with : Flat fiber amorphous iron* ***Source : Author***



Graphe3 : *Determination of the flow time in terms of S/G for a witness concrete (without fiber)* ***Source : Author***

5. INTERPRETATION OF CURVES:

The hook fiber has a S / G ratio (sand / gravel) optimum of 0.7, to the percentage of 0.5% fibers **(Cf. GRAPH 1)**.

While the flat fiber has a S / G ratio (sand / gravel) optimum which is 1 percent of 0.5% fibers **(Cf. GRAPH 2)**.

It should be noted that the percentage of plasticizer was kept constant and is 0.05% of the cement weight. The shortest flow time was marked by the use of the flat fiber (8 seconds) for a S / G = 1, while our witness concrete had recorded a time of 15 seconds for an S / G = 0.55.

The optimization of the formulation of these two types of concrete with fiber hook or flat fiber , doesn't only depends on the ratio S / G and used type of fiber (length, shape, snap mode) but also the interaction of two key components, namely matrix / fiber.

And other unavoidable phenomenon affecting the workability of the fibrous concrete is the preferential orientation of fibers called anisotropy. Indeed during casting, the fibers are oriented along the axis of flow and parallel to the walls gradually as the concrete fills the formwork. This is a phenomenon that is difficult to assess.

CONCLUSION:

Developments in concrete material have undoubtedly led to new applications where, the impacts cannot be underestimated.

We have in this present article, the concrete material treated for the different feature values that will optimize the formulation of a conventional concrete, and then we used for the formulation of a fibrous concrete.

Therefore, we used two types of fiber: the hooked fiber (60mm), and the flat fiber (31mm), and that at the same dosage (0.5%). The variation of the S / G ratio, allowed us to determine the flow time necessary to obtain a material having adequate workability. Thus, it was found that the addition of fibers in the concrete matrix modifies a characteristic of concrete namely its workability, or maneuverability.

The addition of the flat fiber has improved maneuverability of our FRC, by comparing the flow time of the fiber reinforced concrete with flat fiber than the control concrete. We noticed that for S / G ratio of 1, the flow time is equivalent to eight seconds. At the other side, the hooked fiber where a S / G equal to 0.7 the necessary flow time was 15 seconds.

The difference in the S / G ratio is related to the magnitude of the surface area of the amorphous iron fibers require more fine, thereby to ensure the cohesion between the aggregates and fibers.

Therefore we can deduce that to increase the maneuverability of a FRC the use of short fiber and considerable surface area will be the appropriate choice, while the use of longer fiber hook, adhesion fiber- Matrix, therefore improving the mechanical behavior of the FRC.

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